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(19) (CA) **APPLICATION FOR CANADIAN PATENT** (12)

(54) Tent Incubator for Premature Infants (Newborns) with
On-Wall Heating System and Controlled Temperature and Humidity

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(57) 14 Claims

Notice: This application is as filed and may therefore contain an
incomplete specification.

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ABSTRACT OF THE DISCLOSURE

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An improved baby incubator is provided herein. The improvement resides in the provision of heating elements within 5 walls thereof.

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This invention relates to baby incubators.

Existing baby incubators are deficient in terms of providing effective thermoregulation and humidity regulation inside the incubator. The heat supply and ~~the humid air~~^{is} are not evenly distributed around the newborn baby. Overhead infrared heat radiators produce similar problems: extreme changes in the temperature inside the incubator renders such heater problematic. Furthermore, the open-top structure of conventional baby incubators does not allow for humidity regulation within the baby incubator itself. The humidity around the infant is generally thus nursery humidity is increased, causing significant discomfort to the treating staff. that of the baby nursery itself; there is no humidity regulation for the baby incubator itself. ~~On the other hand,~~ Hot air flow incubators are cumbersome and suffer from similar problems of heat distribution and thermoregulation.

Accordingly, objects of aspects of the present invention are: to provide a heating system that will provide heat by radiation and convection with maximal even distribution; to provide an inexpensive frame-and-tent type structure of a simple design that enables easy assembly of the baby incubator; to provide the option of being able to dispose of parts of the incubator or to re-sterilize (the on-frame mounted tent) in order to enhance the clean environment inside the baby incubator; to provide special opening structures, having a large number of optional openings, to allow easy access into the interior space of the baby incubator to facilitate routine care of the newborn baby, without excessive loss of heat or humidity from within the baby incubator to the ambient environment and to provide versatility in access to the newborn baby; and to provide a double layered wall

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structure for the walls of the tent, including the openings, to avoid excessive heat loss to the ambient environment when all the openings are closed, in order to save energy.

By a broad aspect of this invention an improvement is provided in a baby incubator by means of the provision of heating elements within walls thereof. Preferably, the walls are flaccid and are supported on a fixed framework.

In another variant, the walls include opening flaps controlled by a ZIPPERTM and/or by a VELCROTM mechanism and/or a magnetic sealing mechanism. In another such variant, the baby incubator includes an arrangement of magnetizable metal strips along free edge of opening flaps and corresponding magnetic strips on the fixed frame or fixed parts of the ^{walls of the tent} incubator.

In still another variant, the baby incubator includes an air temperature sensor hanging in mid-air in air space surrounded by the walls of the incubator. In such variants, the baby incubator may include means to control the temperature within the incubator and/or means to control the humidity within the incubator.

In a still further variant, the baby incubator includes apertures in the fixed frame and ^{in the} ~~any~~ fixed parts of tent, and/or ~~includes reclosable openings, openings in the walls of the incubator,~~ and/or reclosable ZIPPERTM openings in the walls of the incubator.

In yet another variant, the baby incubator includes means for elevation of a mattress off a floor of the incubator.

In a still further variant, the baby incubator includes hot air blower means, and/or self-heatable double layered walls ^{by} means of ^{heating} element incorporated in the internal layer; Air layer between the walls enhances isolation of the internal layer and reduces heat loss to the immediate +

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By another aspect of this invention an incubator is provided comprising: a tent-like arched structure having a floor, two transparent opposed arch-shaped end walls and a transparent covering secured to the arch-shaped end walls; a plurality of
5 electrical heating elements operatively associated with all ^{or part} of the exposed interior surfaces; at least one openable and reclosable flap to allow access to the interior of the tent-like structure; means within the tent-like structure to sense and control the temperature therewithin; means within the tent-like
10 structure to sense and control the humidity therewithin; means for the evacuation of accumulated CO₂ from within the tent-like structure; and means for the introduction of oxygen and aspiratory medication to provide a controlled atmosphere within the tent-like structure.

15 ~~The framework for the end walls preferably are made of "synthetic" plastic material.~~ The frameworks for the end walls and the longitudinal walls preferably are made of a rigid plastic, e.g., LUCITE_{TM}, high density polyethylene, polypropylene or nylon. The walls covering the framework preferably are of a
20 flaccid plastic sheet, e.g., polyethylene film. The heating means preferably are heating wires arrayed in a protected serpentine fashion along or within all ^{or part} the walls of the incubator.

The flaps preferably are provided by all the flaccid plastic
25 sheets, and are held to the ^{rest of the tent flaps, fixed part or to the} framework by a sliding reclosable fastener (known by the trade-mark ZIPPER_{TM}), or by the loop-type reclosable fastener (known by the trade-mark VELCRO_{TM}) or by magnetic strips.

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A semi-cylindrical shaped tent (or treasure chest) made of thick flexible or bendable plastic, e.g., polyethylene or any soft, transparent isolating material, ^{comprising a heating element and} mounted on a frame, thus constitutes the main element of the invention. Long metal warming elements (resistors) are incorporated in the transparent plastic walls of the incubator in a convulated form to generate heat (up to 40°C, i.e. from 20°C to 40°C) that warms the whole exposed inner surface areas of the tent evenly. In the optional double-layer-wall, the wire element is incorporated in the internal layer of the baby incubator, namely, the layer that faces the air-space of the baby incubator. Heat from all the walls of the tent including (the floor) evenly heats the whole space inside the baby incubator by convection and radiation. The configuration of the warming elements is such that every segment of surface area is heated evenly. The warming element is preferably in a winding form laminated between two sheets of plastic forming the baby incubator. The loops of the winding element lie close to each other, and are preferably parallel to each other; they constitute one continuous wire from the point of entry of the electric current to the point of exit. An optional feature is a division of the convulated wire into several sub-units of heating elements, with several separate points of entry and exit of the electric current.

Temperature sensors placed within the baby incubator, hanging from the roof of the baby incubator to the mid-air space inside the baby incubator as well as on the infant, ^{skin and rectum,} are provided to measure the temperature. The measurements are relayed to a thermo-regulation device outside the incubator which, in turn,

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following the readings, enables controlling the air-space temperature inside the baby incubator at a desired degree without sharp fluctuations.

5 A humidity sensor inside the baby incubator (e.g., mounted on one of the rigid frames) conveys signals to an external humidity control system that controls a wall-mounted humidifier within the baby incubator to humidify the air to a desired fixed humidity level.

10 A very small hot air flow device may be mounted on the frame of the baby incubator to ensure a constant small air flow from the baby incubator to the external environment to allow evacuation of accumulating CO₂ (from the breathing of the infant) from the air-space to the external environment.

Openings for major access are provided by flaps on all the 15 sides of the baby incubator and on its rounded roof. Opening for minor access are ZIPPER_{TM} controlled openings within the flaps.

Optional apertures for increased and controlled oxygen supply and for aspiratory medications administration may also be placed in the rigid frame (head side) of the incubator. 20 Corresponding holes, for these apertures as well as for the various mounted accessories (e.g., humidifier, hot air blower etc.), may be cut out from the overlaying part of the baby
| tent incubator. Additional holes may be drilled on the frame and
° corresponding holes may be cut in the covering of the baby
tent
25 incubator as may be necessary for mounting any additional accessory instruments.

The accessories are tightened onto the frame and adjacent tent to seal the borders of the apertures, ~~against any heat and humidity leak.~~

In the accompanying drawings;

5 Figure 1 is a perspective view of the baby incubator of one embodiment of this invention; and

Figure 2 is a schematic perspective view of an alternative wall structure.

As seen in Figure 1, the baby incubator (C) includes two
10 main parts, namely the skeleton frame (A) and the cover (B) which is mounted on the frame (A).

The skeleton frame (A) consists of two longitudinally-spaced-apart transparent thick plastic semi-circular angled, or
| double-^{wing}ring^{and}s ~~of~~ arch-shaped members (1) and (2) which form
0 the head and the tail of the incubator (C). These members are
15 formed of any suitable synthetic plastic material, e.g., PLEXIGLASSTM, PERSPLEXTM or other acrylate-type polymers, high density polyethylene, polypropylene, etc. These two members (1) and (2) are connected by four longitudinally-extending bars (3),
20 (4), (5), and (6). Bars ³(4) and ⁵(6) are also angled, thus forming panels which are parallel to the sides (9) and (10) respectively of the cover (B). Bars ³(4) and ⁵(6) ^{also} provide panels
which are parallel to the floor (40) of the baby incubator (C).
and the semi-circular rings
These bars form a skeleton on which the cover (B) is mounted to
25 form a closed heated space.

The cover (B) is made of a transparent flaccid plastic which includes a heating element therein. Suitable such flaccid plastic sheets are those made of polyethylene. The heating

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Preferably

element, which is in a form of wire (7), is incorporated in all the exposed internal walls of the tent and on the roof and the floor (40) as well. Such wires (7) are shown only in wall (9) for clarity. One suitable manner of providing such wires is to

5 lay a course of wires in a serpentine pattern on one (bottom) sheet and to laminate a similar (top) sheet, which is laid atop the wires, to the bottom sheet. These heating elements act as resistors when appropriate electric current is passed through them. The current is controlled to be such that a temperature

10 of up to 40°C, i.e. 20°C to 40°C, is provided on the plastic covers (B). The heating elements (7) then heat the plastic covers (B) which in turn provide heat, by convection and radiation, to the air space within the interior of the baby incubator. In addition, the wire elements (7) themselves provide

15 heat directly to the air space within the inside of the baby incubator by direct convection and radiation. The electric current supply to the heating elements (7) are by means of electrically conductive wires (41) which enter the baby incubator (C) through two points of entry and exit (8).



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20 This configuration of the baby incubator (C) with the heating wires distributed over all of the interior surfaces allows even heating, at a constant desired temperature, of the cover (B) of the baby incubator (C) and in turn allows even heating of all interior space within the baby incubator (C).

25 To allow access to the infant with minimal heat loss, the cover (B) is provided with opening flaps at 5 locations namely: (9) on one side of the baby incubator (C) which is the exposed front side; (10) on the opposite side of the baby incubator (C);

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(11) on the head side; (12) on the tail side; and (13) on the roof. These flaps, (9), (10), (11), (12) and (13) are, thus in effect, ^{major part of the} ~~the~~ tent covers (B). ^{The rest is the fixed part of the tent that is adjacent to the frame hard frame.}

The panels of flaps (9), (10), (11), (12) and (13) are
5 arranged to open or to close hermetically by a closure line structured as a ZIPPER_{TM} or a VELCRO_{TM} or a magnetic type which, incidentally is the most hermetic type of closure. Taking flap (9) as an example, it is secured permanently at its upper edge (32) but is provided with vertical and horizontal reclosable
10 fasteners (31) and its three other edges. The closure/opening (31) line is marked by the "zebra" stripes at the edges of the flap (9). In other words, the "zebra" line (31) is where the closure mechanism is constructed. The "zebra" line (31) is always of a U-shape, where the bottoms and sides of the "U"
15 represent the opening part and the open part of the "U" represents the part of the flap that cannot be opened, and thus is part of the cover (B) of the baby incubator (C).

All other flaps (10), (11), (12), and (13) are constructed to be structurally similar to flap (9) and to operate in the same
20 manner.

If VELCRO_{TM} mechanism is used for the reclosable fastener, the penetrating part is on the flap and the receptive part is on the fixed part of the wall of the baby incubator (C). The fixed panel is secured to the skeletal framework defined by the
25 longitudinally-extending bars (3), (4), (5), and (6) and by the framework of the arches (1) and (2). If a magnetic mechanism is used, strips of magnets are attached to the ^{tent} ~~the~~ framework defined by the longitudinally-extending bars (3), (4), (5) and (6) and by

the framework of the arches (1) and (2), on the stripes that correspond to the "zebra" stripes (31).

For the sake of clarity, the wires (7) within the flaps (10) for the opposite side, (12) for the tail side and (3) for the top are not shown. However, they are similar to the side flaps (9) and the head flaps (11).

The opening flaps include the convoluted heating wires. Thus, efficient heating continues even when the flap is slightly opened and elevated to allow hands penetration into the tent space for handling and treatment of the infant.

Another ^{optional} optical feature is the provision of means (e.g. ZIPPERS_{TM}) (42) which extend vertically along the flap (9) as well as along the flap (10). In addition, such means are also provided in flaps (11) and (12) to permit access at the head and foot of the baby incubator (C). This feature allows access for short interventions at various optional locations. The ZIPPER_{TM} is opened just enough to allow penetration of hands, thus minimizing the heat loss from the opening.

Similar openings (i.e. ZIPPER_{TM} controlled) are placed in the frame panel (1) of ^{the part of} the baby incubator (C) near the head side to allow intravenous lines, ^{monitoring lines} etc., into the air space within the baby incubator (C), from an outside source (e.g. an I.V. bottle) or destination equipment (e.g., monitoring equipment, e.g., electrocardiogram, skin oxygen, etc.).

Another such opening (e.g., a ZIPPER_{TM} controlled opening) is located on the frame panel of the baby incubator (C) near the foot panel (2) to allow exit of various treatment lines, e.g.,

urinary catheters, rectal thermometer lines, skin temperature lines, etc.

In both cases, the ZIPPERTM is closed to the point where all lines are on a ^{restricted} ~~retractor~~ bundle, to minimize heat loss at the
5 opening.

There is also the optional features of the placement of monitoring jack outlets in the frame, with corresponding access apertures in the ^{tent frame} ~~frame~~ part of the baby incubator (C).

A heat sensor (thermometer) (14) hangs from the frame (4),
10 the baby incubator (C) lies in mid-air of the baby incubator space to allow continuous measurement of the air temperature inside the baby incubator. A heat sensor (14) is placed on the frame panel (15) of the baby incubator (C) or along any other convenient location to allow measurement of the temperature of
15 the walls of the baby incubator.

The temperature readings are transferred to a heat regulation system (16) which controls the amount (intensity) of current that is transferred to the walls to generate the heat necessary for the desired internal temperature within the baby
20 incubator. As noted hereinabove, the electrical connector is at the exit and entry points (8).

Aperture (17) allows for the introduction of a humidity sensor (43) which measures the humidity inside the baby incubator (C) at a point closest to the head of the infant. The humidity
25 reading signal is transferred along a line (44) parallel to bar (13) to the regulation unit (19) which controls the humidifier (20) which supplies vapour tube (45) and through aperture (17) close to the legs of the infant.

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A small, hot-air blower (21) blows a small amount of air through tube (46) to cause forced evacuation of significant accumulations of CO₂ out of the air space.

Optional is placement of Monitoring jack outlets (not shown) 5 may optimally be placed on the frame (46), with corresponding hole-apertures in the fixed part (1,2) of the baby^{that} incubator.

ZIPPER_{TM} (25) is designed to allow complete opening of the head side from the upper corner of the flap to the top of the roof (13). Opening the ZIPPER_{TM} will allow a wide aperture 10 through which the baby incubator could be mounted over the frame (3,4,5,6). Similar solution are ZIPPERS_{TM} on both upper corners of the side flaps, connecting to the lower part of the roof flap (allowing temporary openings on the fixed part of the side of the cover). This allows huge openings for mounting the cover on the 15 frame, then closing the ZIPPER_{TM} when the frame (3,4,5,6) is inside the cover.

Six flat-topped, mushroom-like structures (47) are used as a base for elevation of a mattress (with hard bottom) or laying a hard rectangular, elevated plastic base on which a mattress is 20 layed. Four are arranged on each of the four corners of the horizontal panel of the rectangular bottom of the frame, and two on the horizontal panels of the longitudinal bars (3) and (4) in a midshaft position.

This elevation is necessary to avoid contact of the mattress 25 with the wire-heated ^{floor} ~~air~~-flow. This forms an air-space below the mattress. Since the mattress or rectangular hard plastic base ^{smaller than} ~~are as small as~~ the floor frame, hot air generated by the floor element could flow upwards to the main air compartment within

which the infant is surrounded through the spaces between the mattress and the walls of the tent.

An optional feature for heat loss reduction is shown in Figure 2. In this option, the walls of the baby incubator are double layered. The internal layer (50) incorporates the loops of the heating element (7) and is adjacent to the air-space of the tent, while the external layer (51) is adjacent to the outside immediate environment. The two layers form an inflated sheet with an intermediate layer (52, 53) of air which isolates the internal wired plastic layer from the external surrounding, thus preventing excessive heat loss and providing an energy-saving measure. The entry and exit of the electric current to the wire legs in Figure 2 are represented by points (52).

Attached as appendix are 2 hand written drafts of the invention as references and proof of inventorship

Voltage drop sensor for automatic disconnection of the electric current in case of short circuits or accidental touch of ~~a torn part~~ exposed element (as a result of a tear in the plastic cover).

Production tip - the wire element is attached to one layer of polyethylene while a second layer glued on it thus securing the element between the two layers

THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE
PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. In a baby incubator, the provision of heating elements
within walls ^{or part of them} thereof.

2. The baby incubator of claim 1 wherein said walls are
flaccid and are supported on a fixed framework.

3. The baby incubator of claims 1 or 2 wherein said walls
include opening flaps controlled by a ZIPPER_{TM} and/or by a
VELCRO_{TM} mechanism and/or a magnetic sealing mechanism.

4. The baby incubator of claims 1 or 2 including an air
temperature sensor hanging in mid-air in air space surrounded by
said walls of said incubator.

5. The baby incubator of claim 2 including apertures in
the fixed frame and any fixed parts of tent.

6. The baby incubator of claims 1 or 2 including
reclosable openings, openings in said walls of said incubator.

7. The baby incubator of claims 1 or 2 including
reclosable ZIPPER_{TM} openings in said walls of said incubator.

8. The baby incubator of claims 1 or 2 including means for
elevation of a mattress off a floor of said incubator.

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9. The baby incubator of claims 1 or 2 including an arrangement of magnetizable metal strips along free edge of opening flaps and corresponding magnetic strips on the fixed frame or fixed parts of the ^{tent} incubator.

10. The baby incubator of claims 1 or 2 including means to control the temperature within said incubator.

11. The baby incubator of claims 1 or 2 including means to control the humidity within said incubator.

12. The baby incubator of claims 1 or 2 also including hot or cold air blower means.

13. The baby incubator of claims 1 or 2 also including self-heatable, double layered walls.

14. An incubator comprising:

a tent-like arched structure having a floor, two transparent opposed arch-shaped end walls and a transparent covering secured to the arch-shaped end walls;

a plurality of electrical heating elements operatively associated with all of the exposed interior surfaces;

at least one operable and reclosable flap to allow access to the interior of the tent-like structure;

means within the tent-like structure to sense and control the temperature therewithin;

means within the tent-like structure to sense and control the humidity therewithin;

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means for the evacuation of accumulated CO₂ from within
the tent-like structure;

and means for the introduction of oxygen and aspiratory
medication to provide a controlled atmosphere within the tent-
like structure.

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